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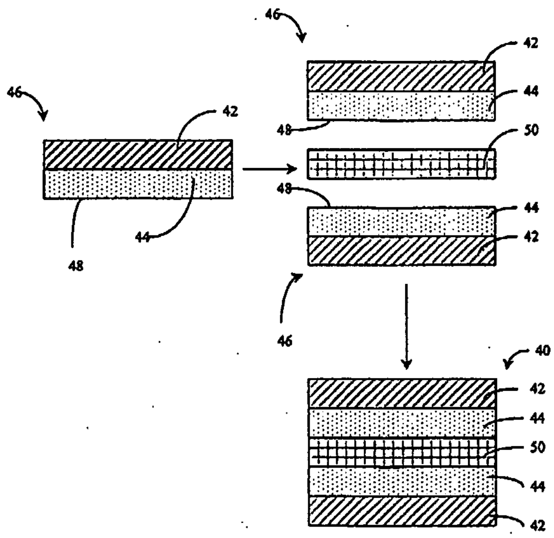
(54) **STRATIFIES DE FILM MINCE**
(54) **THIN FILM LAMINATES**



(57) A copper clad laminate for multilayer interconnected printed circuit boards consisting of an adhesive-resin coated copper foil bonded to a thin liquid crystal polymer film is disclosed. Also disclosed are laminates made from liquid crystal polymer films reinforced with dry woven and non-woven fabrics, papers, scrims, etc. A variety of resin systems can be used to coat the copper foil including both thermoplastic and thermoset polymers. As compared to copper clad laminates made with traditional resin impregnated fabrics, the thin film laminate provides an ultra smooth copper surface, a more uniform dielectric constant, improved drillability, dimensional stability, and laser/plasma micro via compatibility. Furthermore, the disclosed laminate can be used in multilayer printed circuits at a thickness much less than traditional copper clad laminates.

THIN FILM LAMINATES

BACKGROUND

Technical Field

This invention relates to copper clad laminates used in multilayer printed circuits, and more particularly, to resin rich copper clad laminates having thin film support.

Discussion

Multilayer printed circuits find use in a variety of electronic applications. For example, they furnish structure for mounting semiconductor components, and provide the primary interconnection between discrete components in most computing systems such as desktop and laptop computers. These circuits continue to evolve in complexity and density as semiconductors and systems become more complex. More advanced multilayer printed circuits are referred to as Multichip Modules, High Density Interconnects, Micro Via Multilayers, and PCMCIAs.

Copper clad laminates provide the electrical insulation and the physical structure for each of the individual circuit layers of a multilayer printed circuit. In some cases, the copper clad laminates themselves function as application components, such as passive capacitors, as in ZYCON BURIED CAPACITANCE technology, for example.

Conventional copper clad laminates, which were invented by Park Electrochemical Corporation in the late 1950s, are comprised of three main components—copper foil, thermosetting resin, and woven or non-woven fabric reinforcement. Generally, the copper foil is about 35 microns thick and is made by an electrodeposition process. Often, one or both sides of the copper foil are treated to improve adhesion to the fabric reinforced thermosetting resin.

A conventional copper clad laminate 10, as shown in FIG. 1, is typically manufactured using a three step process. In the first step, the woven fabric 12 is coated or impregnated with the thermosetting resin (not shown), forming what is known as a prepreg 14. To improve handling and bonding, the prepreg 14 is usually

partially cured—or B-staged. In a second step, the prepreg 14 is disposed between two copper foils 16. In a third and final step, the prepreg 14 and the copper foils 16 are bonded together with heat and pressure to form the finished laminate 10.

Although conventional copper laminates have enjoyed widespread success, they are not without problems. Conventional copper laminates depend on precise control of the resin chemistry for successful resin impregnation of the woven fabric and curing of the prepreg. Insufficient curing will cause excessive flow of the resin during the bonding process, which can result in uneven final laminate thickness. Excessive curing can result in poor flow during the bonding process, which produces voids in the finished laminate. Uneven laminate thickness and voids degrade the performance of the multilayer printed circuit.

More significantly, the resin content of prepregs in conventional copper clad laminates normally ranges between 40 and 70 wt. %. Manufacturers avoid generating a resin rich layer—greater than about 70 wt. % resin—adjacent to the copper foil because such layers are difficult to establish and control during the bonding process. But, relatively low solids loading of the dielectric layer results in local variations in resin and fiber content throughout the laminate. These variations are caused by a non-uniform fiber distribution in both woven and non-woven fabrics used in laminates. In woven fabrics, high fiber densities occur at filament crossover points; in non-woven fabrics, fibers are randomly distributed and often exhibit local regions of high and low filament density.

The local variations in resin and fiber content can cause manufacturing problems such as dimensional instability, difficulties in conventional drilling of holes through high density fiber crossover points, and complications in plasma or laser drilling of partial or through holes. For example, many copper clad laminates employ E-Glass fiber reinforcement, which resists laser ablation and plasma etching.

More importantly, local variations in resin and fiber content can cause variability in the electrical performance of very fine line circuitry, especially when the circuitry is carrying high-speed digital or analog signals. A non-uniform fiber distribution directly relates to slight, local differences in dielectric constant and

dissipation factor. These slight differences can cause signal speed to vary from point to point in the laminate, and can degrade signal integrity, which sometimes results in system problems in the finished computer.

Finally, in ultra-thin applications of traditional copper clad laminates, small discontinuities in the resin or the fabric can lead to electrical breakdown at voltages of about 500 V. This electrical breakdown can cause reliability problems in applications where the resin-fiber dielectric layer separates a positive and negative voltage such as in a power supply interconnect.

Manufacturers of copper clad laminates have sought to overcome these problems by developing so called flexible laminates, which replace fiber reinforcement with a polymeric film. There exist two important subclasses. In the first subclass, a polyimide film replaces the fabric reinforcement. A "prepreg" is formed by resin coating the film, and is bonded to a copper foil under heat and pressure in the same manner as conventional copper clad laminates. In the second subclass, called "adhesiveless flex copper clad laminates," copper is sputter coated or electroplated on the external surfaces of the polymeric reinforcing film, which obviates the need for the heat and pressure cycle.

Flexible laminates solve many of the difficulties resulting from variations in the resin and fiber content, but pose additional problems. For example, flexible laminates suffer from high material costs associated with using a relatively thick film as a substrate material. Generally, the copper foil used in flexible laminates is very thin—about 12 microns—and ideally, the dielectric should have a similar thickness. However, a 12 micron polyimide film is much too fragile to be resin coated, and therefore polyimide films of about 25 microns or greater are used. Although manufacturers have successfully used sub-12 micron, resin impregnated porous films of polytetrafluoroethylene in flexible laminates, PTFE film is relatively expensive. Moreover, flexible laminates made from PTFE films have experienced dimensional instability because of the cold flow characteristics of such films.

The present invention is directed to overcoming, or at least minimizing, one or more of the problems set forth above.

SUMMARY OF THE INVENTION

According to the invention, a resin rich copper clad laminate comprises a copper foil, an adhesive resin layer, and a liquid crystal polymer film. The adhesive resin layer is disposed between and bonded to the copper foil and the liquid crystal polymer film. In one embodiment, the laminate further comprises a second copper foil and a second adhesive resin layer and the second adhesive resin layer is disposed between and adhesively bonds the second surface of the liquid crystal polymer film and the second copper foil.

In one embodiment, the first copper foil has a matte surface and a smooth surface and the first adhesive resin layer is disposed on the matte surface. In another embodiment, the smooth surface has been treated to promote adhesion and the first adhesive resin layer is disposed on the treated smooth surface. The first copper foil can be between about 12 and about 70 microns thick.

Preferably, the first adhesive resin layer is comprised of at least one of epoxy, cyanate ester, bismaleimide triazine resin, polyimide, polytetrafluoroethylene, polyphenylene ether, polyphenylene oxide, polyester, or liquid crystal polymer. Normally, the thermosetting resins are B-staged, and preferably, contain fillers to minimize shrinkage. Suitable fillers include, but are not limited to, mica, clay, TiO_2, $BaTiO_3$, Boron Nitride, glass fiber, aramid fiber, or liquid crystal polymer fiber, either alone or in combination. The first adhesive resin layer can be between about 12 and about 100 microns thick.

The first surface of the liquid crystal polymer film can be treated to improve adhesion to the resin as, for example, by plasma etching or by sputter coating an adhesion promoter. The liquid crystal polymer film is preferably between about 6 and about 75 microns thick. Moreover, the liquid crystal polymer film further comprises a reinforcing material that can be at least one of a dry woven fabric, non-woven fabric, paper, and scrim.

Further, according to the invention, a method of making a resin rich copper clad laminate includes the steps of coating a surface of a copper foil with a resin; disposing the coated surface of the first copper foil on a surface of a liquid crystal

polymer film; and laminating the first copper foil to the liquid crystal polymer film. Typically, the laminating step will be carried out by applying heat and pressure to the laminate.

In a preferred embodiment, the method further comprises the steps of coating a surface of a second copper foil with the resin, disposing the coated surface of the second copper foil on a second surface of the liquid crystal polymer film and laminating the second copper foil to the liquid crystal polymer film, preferably by applying heat and pressure. Further, the coated first and second copper foils are disposed on the liquid crystal polymer film simultaneously.

In one embodiment, the first copper foil has a matte surface and a smooth surface and the coating is applied to the matte surface. In another embodiment, the first copper foil has a matte surface and a treated smooth surface and the coating is applied to the treated smooth surface.

The resin can be one or more of the following: epoxy, cyanate ester, bismaleimide triazine resin, polyimide, polytetrafluoroethylene, polyphenylene ether, polyphenylene oxide, polyester, or liquid crystal polymer. Preferably, the resin is a low shrinkage resin that contains a filler. The filler can be any one or more of talc, mica, clay, TiO_2, $BaTiO_3$, Boron Nitride, glass fiber, aramid fiber, or liquid crystal polymer fiber. The resin is preferably a B-staged thermosetting resin. If desired, the first surface of the liquid crystal polymer film can be treated to improve adhesion to the resin by plasma etching or sputter coating an adhesion promoter.

Preferably, the resin coating is between about 12 and about 100 microns thick, the first copper foil is between about 12 and about 70 microns thick and the liquid crystal polymer film is between about 6 and about 75 microns thick. The liquid crystal polymer film can contain a reinforcing material, such as dry woven fabric, non-woven fabric, paper, scrim, alone or in combination. The laminating step can be one of continuous pressing, static pressing, and passing the first copper foil and the liquid crystal polymer film through roll-to-roll mandrels.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings in which:

FIG. 1 shows an enlarged cross-sectional side view of a prior art copper clad laminate (not to scale);

FIG. 2 shows an enlarged cross-sectional side-view of a first embodiment of a thin film laminate (not to scale) made in accordance with the invention;

FIG. 3 shows an enlarged cross-sectional side-view of a second embodiment of a thin film laminate (not to scale) made in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 2, a first embodiment of a resin rich copper clad laminate 20 can be manufactured using a nominally three step process. In a first step, a copper foil 22 is coated with a resin 24 in order to form a coated copper foil 26. Next, a liquid crystal polymer film 28 is disposed on the resin 24 side of the coated copper foil 26. In a third step, the coated copper foil 26 and the liquid crystal polymer film 28 are bonded together with heat and pressure to form the resin-rich copper clad laminate 20.

Referring now to FIG. 3, a second embodiment of a resin rich copper clad laminate 40, and its method of manufacture is shown schematically. As in the first embodiment, two copper foils 42 are first coated with a resin 44, which results in coated copper foils 46 having coated surfaces 48. Next, a liquid crystal polymer film 50 is disposed between the coated surfaces 48 of the two coated copper foils 46. In a third and final step, the two coated copper foils 46 and the liquid crystal polymer film 50 are bonded together with heat and pressure to form the resin rich copper clad laminate 40.

In both embodiments, the resin/adhesive coating is typically between about 12 and 100 microns thick, and the copper foil is between about 12 and 70 microns thick.

Heat and pressure in the laminating step is supplied by conventional roll-to-roll mandrels, continuous pressing or static pressing.

The thin liquid crystal polymer film provides dimensional stability and good dielectric performance at a cost comparable to fabric reinforcement, but without the associated technical difficulties of fiber-based prepregs. The liquid crystal polymer film can be any suitable thin polymer film such as those described, for example, in Lusignea, et al. "Thin Multilayer Circuit Boards using Liquid Crystal Polymers," presented at "Plastics in Portable Electronics" sponsored by the Electrical and Electronics Division of the Society of Plastics Engineers, Inc., which is herein incorporated by reference. Useful liquid crystal polymers are available from a variety of suppliers including DuPont, Hoechst-Celanese, Amoco Performance Products, Sumitomo Chemical and Unitika under the tradenames ZENITE, VECTRA, XYDAR, SUMIKASUPER, and RODRUN, respectively.

Liquid crystal polymers are thermoplastics having rigid linear molecular chains that tend to arrange themselves into anisotropic regions with preferred directions of orientation. These materials have crystal-like order in the melt state—hence the term liquid crystal polymer—which is retained when the materials are cooled to the solid state. Thus, as pointed out in Lusignea et al., a key to making liquid crystal polymer films is to control the orientation of the molecular chains during the transition from the molten state to the solid state. Liquid crystal polymer films having biaxial orientation are especially useful for making resin rich copper clad laminates. Such films are described in U.S. Patents Nos. 4,871,595 and 4,975,312, which are both herein incorporated by reference, and are available from Foster-Miller, Inc. of Waltham, MA, under the trade name SUPEREX.

Suitable liquid crystal polymer films have a thickness of about 12 microns, but can also range from about 6 microns to about 75 microns. The liquid crystal polymer film can be reinforced by incorporating dry woven and non-woven fabrics, papers, scrims and the like. The adhesion of the liquid crystal polymer film to the resin can be enhanced through various treatments, including reel-to-reel plasma etching and reel-to-reel sputter coating of one or more adhesion promoters such as titanates.

Typically, the copper foil used in the present invention is made by conventional electrodeposition processes described, for example, in U.S. Patents Nos. 3,984,598 and 3,585,010, and as described in Rider et al., Printed and Integrated Circuitry 24-27 (1963). Furthermore, the smooth or shiny surfaces of the foils can be treated to improve adhesion to the resin layer. For example, U.S. Patent No. 4,997,516 discloses a process for creating a reticulated metallic copper microstructure that is capable of forming a strong adhesive bond with a resinous substrate (treatment A). Another suitable treatment is disclosed in European Patent Application 0 250 195. Copper films treated in accordance with U.S. Patent No. 4,997,516 and European Patent Application 0 250 195 are called reverse treat and double treat copper foils, respectively. Though the resin can be coated on either the matte surface or the treated smooth surface of reverse treat and double treat copper foils, the resin is usually coated on the treated smooth surface. European Patent Application 0 250 195, Rider et al. and U.S. Patents Nos. 3,984,598, 3,585,010 and 4,997,516, are herein incorporated by reference.

The adhesive resin can be any suitable resin used in the manufacture of dielectric printed circuit boards, including, but not limited to, epoxy, cyanate ester, bismaleimide triazine (BT resin), polyimide, polytetrafluoroethylene (PTFE), allylated polyphenylene ether (APPE), polyphenylene oxide (PPO), polyester, and liquid crystal polymer, either alone or in combination. Preferably, the thermosetting resins are B-staged. Fillers can be added to the resin to minimize shrinkage that occurs following crosslinking or curing of thermosetting resins. Suitable fillers include, but are not limited to, talc, mica, clay, TiO_2, $BaTiO_3$, Boron Nitride, glass fiber, aramid fiber, and liquid crystal polymer fiber, alone or in combination. Pre-coated copper foils are commercially available from Accurate Plastics, Inc. of Falmouth, Cape Cod, Massachusetts.

In contrast to conventional laminates, copper clad laminates made in accordance with the invention have a resin rich region adjacent to the copper foil, which results in improved performance over conventional fabric prepregs. This difference in resin content is shown in Table 1 below.

Table 1: Resin Content of Thin Film Laminates

	Resin content within 25 microns of copper surface	Resin content in remaining laminate
Traditional Fiber Reinforced Laminate	40-70%	40-70%
Thin Film Laminate	90-100%	40-70%

Laminates produced in accordance with the present invention provide several advantages over traditional copper clad laminates when used to manufacture multilayer printed circuits. These advantages include:

(a) Thin film laminates have a smoother surface than traditional laminates. Traditional laminates have a surface roughness of about 4500 Angstroms. Because of the resin-rich region adjacent to the copper foil, thin film laminates have surface roughness of about 2500 Angstroms or less, which can result in reduced scrap in subsequent photo processing and etching steps of multilayer printed circuit production.

(b) Multilayer printed circuits made with thin film laminates have smoother holes than boards made with conventional fabric reinforced laminates. The resin rich region prevents excessive drill wander caused by non-uniformity of the fiber reinforcement adjacent to the copper foil in conventional laminates. The resin rich region also improves laser drilling because of the low fiber density.

(c) Thin film laminates exhibit more consistent dielectric constant and dissipation factor because of the higher and more uniform resin content adjacent the copper foil. The greater uniformity in electrical insulation properties can result in improved signal integrity in multilayer circuitry.

(d) Thin film laminates have lower dielectric constant due to the higher resin content. Lower dielectric constant provides for higher speeds signal transmission speeds.

(e) Thin film laminates have an improved dielectric due to a virtually pinhole-free laminate and the use of liquid crystal polymer dielectric thin film. Unlike traditional laminates in which a single prepreg separates two foils, the copper foils in thin film laminates are separated by two resin layers, as well as the liquid crystal polymer film. Thus, the probability of two pinholes aligning from one copper foil to another is low. Due to leakage, traditional laminates of about 0.002 inch thickness or less exhibit about a 10% dropout when finished and tested under 500 V. Thin film laminates are expected to have failures in the ppm range.

(f) Thin film laminates should be less costly to manufacture because of the higher processing speeds possible with coating copper as opposed to impregnating fabrics. Also, thin film laminates are made without fabrics, which lowers the cost of raw materials.

(g) Finally, thin film laminates are more adaptable to reel-to-reel processing. They have the potential for sub 1 mil laminates. For example, a copper foil coated with a 0.00025-inch thick resin layer can be bonded to a 0.00025-inch thick liquid crystal polymer film to form a 0.00075-inch thick laminate.

EXAMPLE

The following example is intended as illustrative and non-limiting, and represents a specific embodiments of the present invention.

Five, thin film laminates were made by disposing a 0.002-inch thick liquid crystal polymer film between 17 micron thick copper foils, each foil coated with a 0.001" thick layer f a B-staged epoxy resin. The liquid crystal polymer film was

obtained from Foster-Miller of Waltham, MA under the trade name SUPEREX, and was chemically pretreated to improve adhesion. The copper foils and the liquid crystal polymer film were laminated at a temperature of 350 °F under 200 psi pressure for 1 hour.

Each of the five laminates exhibited smooth copper surfaces. On average, the adhesive strength between the resin and liquid crystal polymer film was about 2 lbs/inch. The measured glass transition temperature of the laminate was about 140°C, and the dissipation constant was about 3.4. The five laminates etched evenly; and each was able to lay flat following etching—a desirable characteristic of multilayer printed circuits.

It is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments will be apparent to those of skill in the art upon reading the above description. Therefore, the scope of the invention should be determined, not with reference to the above description, but instead with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The disclosures of all articles and references, including patent applications and publications, are incorporated herein by reference for all purposes.

CLAIMS

What is claimed is:

1. A resin-rich copper clad laminate comprising:
a first copper foil;
a first adhesive resin layer; and
a liquid crystal polymer film having a first surface and a second surface;
wherein, the first adhesive resin layer is disposed between and adhesively bonds the first copper foil and the first surface of the liquid crystal polymer film.

2. The resin-rich copper clad laminate of claim 1, further comprising:
a second copper foil; and
a second adhesive resin layer;
wherein, the second adhesive resin layer is disposed between and adhesively bonds the second surface of the liquid crystal polymer film and the second copper foil.

3. The resin-rich copper clad laminate of claim 1, wherein the first copper foil has a matte surface and a smooth surface and the first adhesive resin layer is disposed on the matte surface.

4. The resin rich copper clad laminate of claim 1, wherein the smooth surface has been treated to promote adhesion and the first adhesive resin layer is disposed on the treated smooth surface.

5. The resin rich copper clad laminate of claim 4, wherein the copper foil is one of a reverse treat copper foil and a double treat copper foil.

6. The resin rich copper clad laminate of claim 1, wherein the first adhesive resin layer is comprised of at least one of epoxy, cyanate ester, bismaleimide triazine

resin, polyimide, polytetrafluoroethylene, polyphenylene ether, polyphenylene oxide, polyester, or liquid crystal polymer.

7. The resin rich copper clad laminate of claim 1, wherein the first adhesive resin layer is comprised of a low shrinkage resin.

8. The resin rich copper clad laminate of claim 7, wherein the low shrinkage resin contains a filler.

9. The resin rich copper clad laminate of claim 8, wherein the filler is at least one of talc, mica, clay, TiO_2, $BaTiO_3$, Boron Nitride, glass fiber, aramid fiber, or liquid crystal polymer fiber.

10. The resin rich copper clad laminate of claim 1, wherein the first surface of the liquid crystal polymer film has been treated to improve adhesion to the resin.

11. The resin rich copper clad laminate of claim 10, wherein the first surface of the liquid crystal polymer film has been plasma etched.

12. The resin rich copper clad laminate of claim 10, further comprising an adhesion promoter applied to the first surface of the liquid crystal polymer film by sputter coating.

13. The resin rich copper clad laminate of claim 1, wherein the first adhesive resin layer is between about 12 and about 100 microns thick.

14. The resin rich copper clad laminate of claim 1, wherein the first copper foil is between about 12 and about 70 microns thick.

15. The resin rich copper clad laminate of claim 1, wherein the first adhesive resin layer comprises of a B-staged thermosetting resin.

16. The resin rich copper clad laminate of claim 1, wherein the liquid crystal polymer film is between about 6 and about 75 microns thick.

17. The resin rich copper clad laminate of claim 1, wherein the liquid crystal polymer film further comprises a reinforcing material.

18. The resin rich copper clad laminate of claim 17, wherein the reinforcing material is at least one of a dry woven fabric, non-woven fabric, paper, and scrim.

19. A method of making a resin rich copper clad laminate comprising:
coating a surface of a first copper foil with a resin;
disposing the coated surface of the first copper foil on a first surface of a liquid crystal polymer film; and
laminating the first copper foil to the liquid crystal polymer film.

20. The method of claim 19, further comprising the steps of:
coating a surface of a second copper foil with the resin;
disposing the coated surface of the second copper foil on a second surface of the liquid crystal polymer film; and
laminating the second copper foil to the liquid crystal polymer film by applying heat and pressure.

21. The method of claim 20, wherein the coated first and second copper foils are disposed on the liquid crystal polymer film simultaneously.

22. The method of claim 20, wherein the coated first and second copper foils are laminated to the liquid crystal polymer film simultaneously.

23. The method of claim 19, wherein the first copper foil has a matte surface and a smooth surface and the coating is applied to the matte surface.

24. The method of claim 19, wherein the first copper foil has a matte surface and a treated smooth surface and the coating is applied to the treated smooth surface.

25. The resin rich copper clad laminate of claim 24, wherein the copper foil is one of a reverse treat copper foil and a double treat copper foil.

26. The method of claim 19, wherein the resin is an epoxy, cyanate ester, bismaleimide triazine resin, polyimide, polytetrafluoroethylene, polyphenylene ether, polyphenylene oxide, polyester, or liquid crystal polymer, alone or in combination.

27. The method of claim 19, wherein the resin is a low shrinkage resin.

28. The method of claim 27, wherein the low shrinkage resin contains a filler.

29. The method of claim 28, wherein the filler is talc, mica, clay, TiO_2, $BaTiO_3$, Boron Nitride, glass fiber, aramid fiber, or liquid crystal polymer fiber, alone or in combination.

30. The method of claim 19, further comprising the step of treating the first surface of the liquid crystal polymer film to improve adhesion to the resin.

31. The method of claim 30, wherein the treating step comprises plasma etching.

32. The method of claim 30, wherein the treating step comprises sputter coating the first surface of the liquid crystal polymer film with an adhesion promoter.

33. The method of claim 19, wherein the resin coating is between about 12 and about 100 microns thick.

34. The method of claim 19, wherein the first copper foil is between about 12 and about 70 microns thick.

35. The method of claim 19, wherein the resin is a B-staged thermosetting resin.

36. The method of claim 19, wherein the liquid crystal polymer film is between about 6 and about 75 microns thick.

37. The method of claim 19, wherein the liquid crystal polymer film contains a reinforcing material.

38. The method of claim 37, wherein the reinforcing material is a dry woven fabric, non-woven fabric, paper, scrim, alone or in combination.

39. The method of claim 19, wherein the laminating step comprises one of continuous pressing, static pressing, and passing the first copper foil and the liquid crystal polymer film through roll-to-roll mandrels.

40. The method of claim 19, wherein the laminating step comprises applying heat and pressure.

ABSTRACT

A copper clad laminate for multilayer interconnected printed circuit boards consisting of an adhesive-resin coated copper foil bonded to a thin liquid crystal polymer film is disclosed. Also disclosed are laminates made from liquid crystal polymer films reinforced with dry woven and non-woven fabrics, papers, scrims, etc. A variety of resin systems can be used to coat the copper foil including both thermoplastic and thermoset polymers. As compared to copper clad laminates made with traditional resin impregnated fabrics, the thin film laminate provides an ultra smooth copper surface, a more uniform dielectric constant, improved drillability, dimensional stability, and laser/plasma micro via compatibility. Furthermore, the disclosed laminate can be used in multilayer printed circuits at a thickness much less than traditional copper clad laminates.

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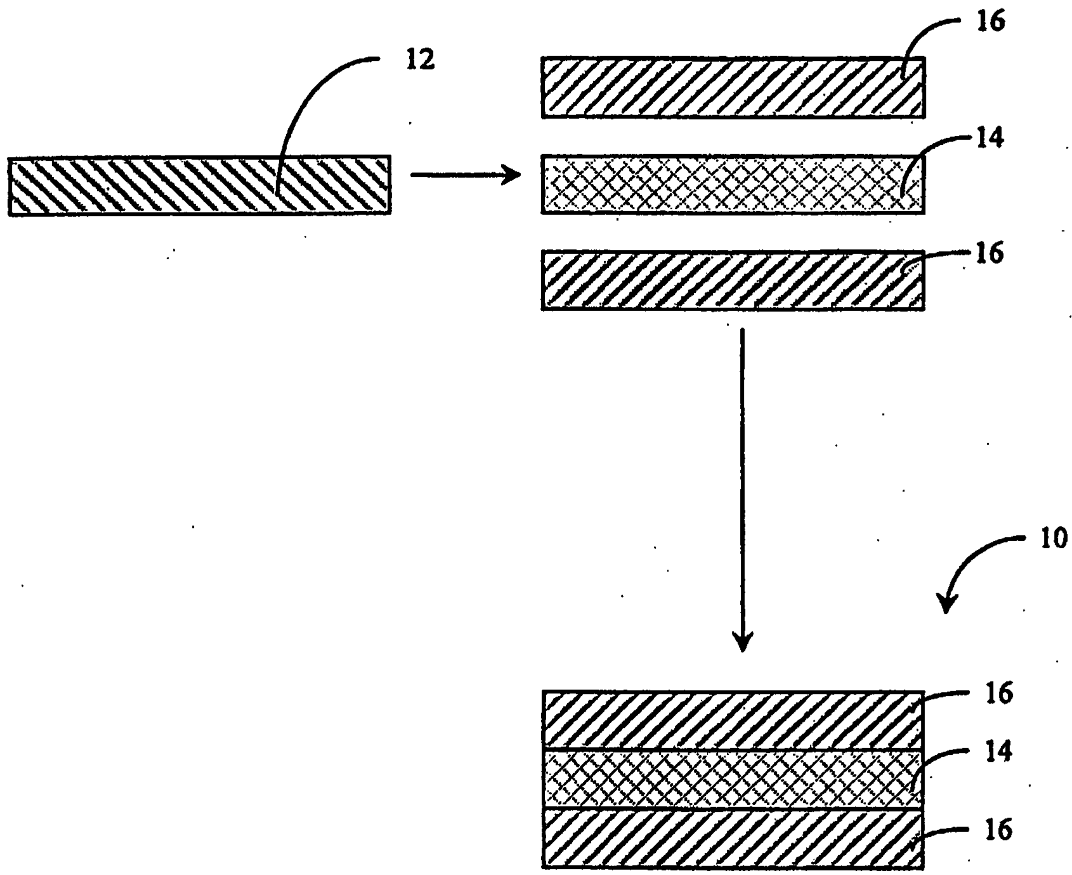

PRIOR ART
FIG. 1

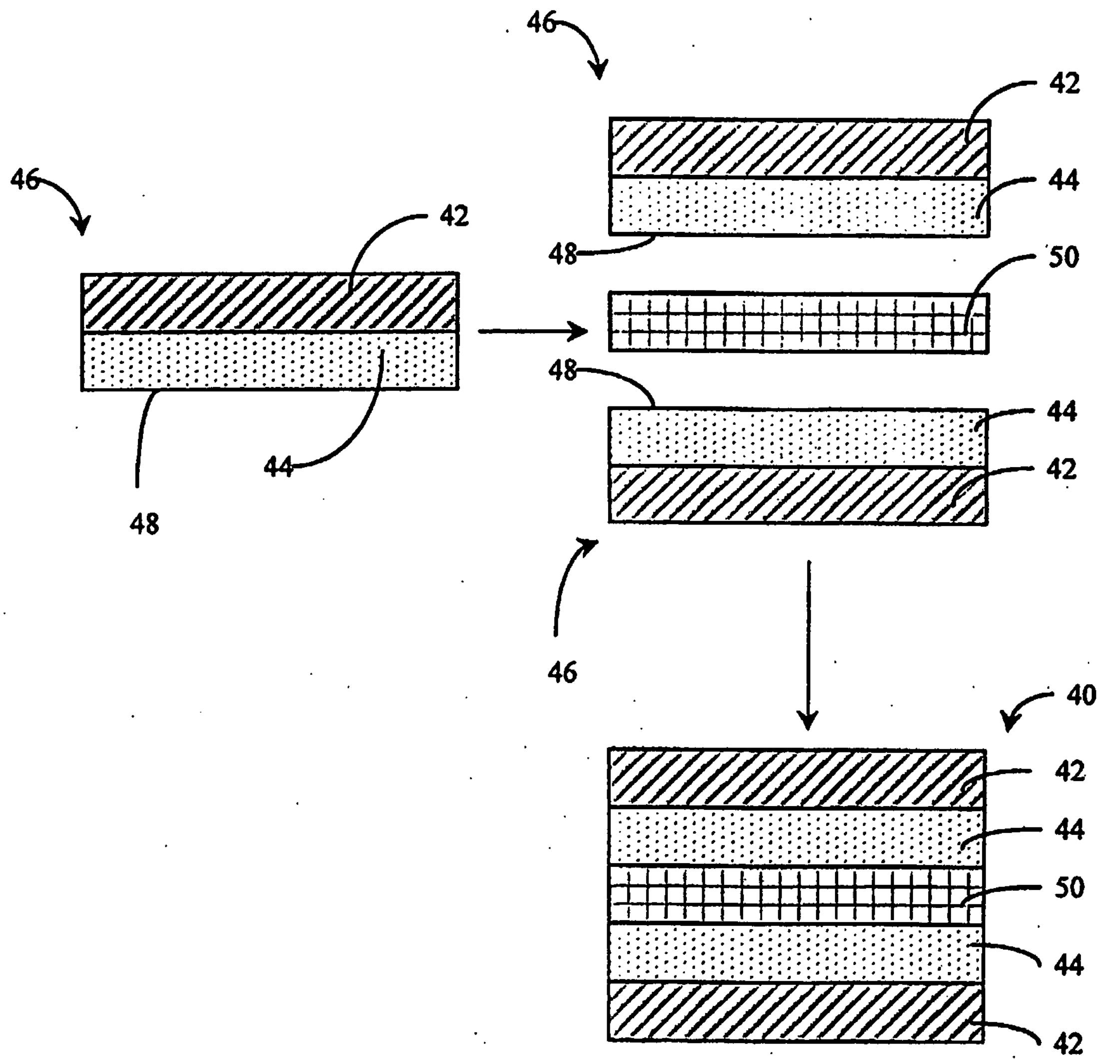

FIG. 3